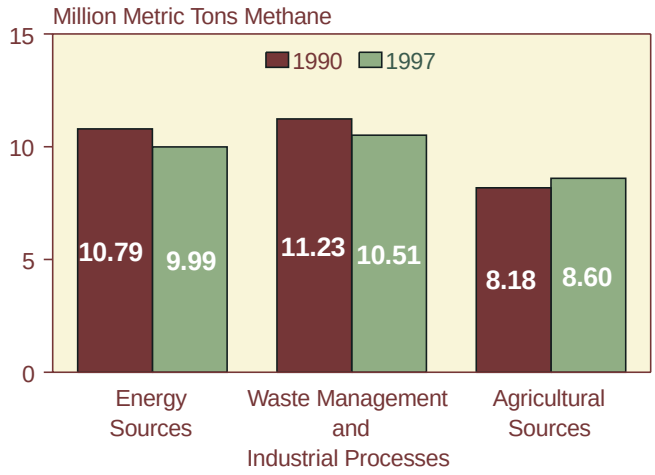
4. Reducing Methane Emissions

U.S. anthropogenic (human-caused) methane emissions total more than 29 million metric tons annually. Because the heat trapping capacity of methane is 21 times that of carbon dioxide integrated over a 100-year horizon, U.S. methane emissions are equivalent to more than 600 million metric tons of carbon dioxide per year. Thus, methane represents just under 10 percent of all U.S. greenhouse gas emissions. There are three major sources of U.S. methane emissions: waste management, agriculture, and energy production and consumption. Methane emissions typically are either accidental or the byproduct of biological processes. Thirty-six percent of the U.S. total can be attributed to the anaerobic decomposition of waste, 33 percent to fugitive emissions from coal mines or oil and gas systems, and 30 percent to agricultural activities (primarily, the management of domesticated livestock) (Figure 12).

Figure 12. U.S. Methane Emissions by Source, 1990 and 1997



Source: Energy Information Administration, *Emissions of Greenhouse Gases in the United States 1997*, DOE/EIA-0573(97) (Washington, DC, October 1998), p. 28.

Between 1990 and 1997, U.S. methane emissions declined by about 1 million metric tons or 3.6 percent. The drop can be attributed to a 1.1 million metric ton decrease in emissions from coal mining and a 0.7 million metric ton decrease in emissions from landfills.[37] The declines occurred despite increases in activity data for both the coal mining and waste management sectors. In 1997, U.S. coal production reached a record level of nearly 1.1 billion metric tons, but industry consolidation moved production away from the Nation's gassiest mines. At the same time, a record level of waste generation was offset by increased recycling and waste combustion, reducing the volume of waste susceptible to decomposition in landfills.

Beyond source reduction, U.S. emissions were further reduced by methane capture. At landfills, wells are drilled into the waste and a vacuum pulls out landfill gas, including methane, before it can migrate out of the landfill. At coal mines, wells may be drilled to degasify a coal seam before mining or down through the gob (collapsed portion of a coal seam) to capture gas during mining operations. Between 1990 and 1997, the level of methane recovery for energy from coal mines rose by 0.7 million metric tons. During the same period, methane recovery for energy from landfills also grew from 0.9 to 1.7 million metric tons.

Overview of Projects Reported

Forty-four organizations, including 13 gas resource developers and 26 utilities, reported a total of 100 projects to reduce methane emissions, an 11-percent increase from the previous reporting year and a 133-percent increase from the first (1994) reporting cycle (Table 7). Twenty-five projects were submitted for the first time in the 1997 reporting cycle, as compared with 35 projects reported for the first time in 1996. A number of projects reported in 1996 were not reported in the 1997 reporting cycle. Because the Voluntary Reporting Program schedule was accelerated to compile reduction data in the year subsequent to its occurrence, some respondents chose to wait for the 1998 reporting cycle.

The average methane emission reduction project achieved a reduction of 8,835 metric tons of methane—or 185,530 metric tons carbon dioxide equivalent—in 1997. Three large projects significantly raised the overall average for all reported projects. First, MCNIC Oil and Gas Company recovered methane from coal mines, lowering emissions by 228,000 metric tons. Second, the 65 waste-to-energy plants operated by members of the Integrated Waste Services Association (IWSA) burned municipal solid waste (MSW) rather

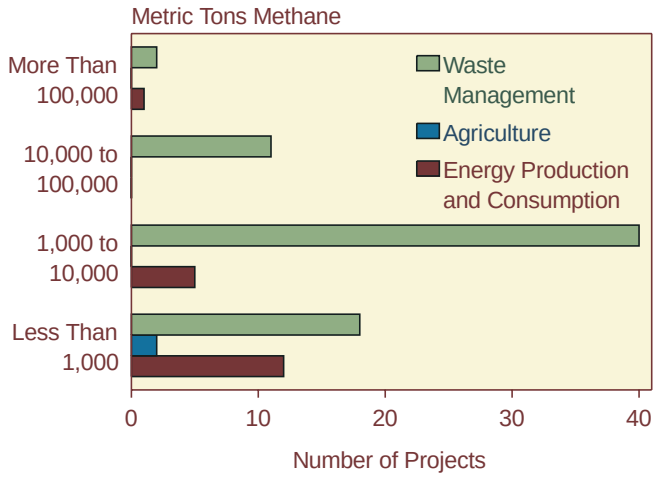
[37] Energy Information Administration, *Emissions of Greenhouse Gases in the United States 1997*, DOE/EIA-0573(97) (Washington, DC, October 1998), p. 36, http://www.eia.doe.gov/oiaf/1605/1605a.html.

Table 7. Methane Reduction Projects Reported by Project Type, Data Years 1994-1997
(Million Metric Tons)

Project Type	1994	1995	1996	1997
Waste Management and Disposal	27	39	65	79
Agriculture	3	3	3	3
Energy Production and Consumption				
Coal Mining	2	2	4	5
Natural Gas Production, Transmission, and Distribution	11	14	18	13
Total	**43**	**58**	**90**	**100**

Source: Energy Information Administration, Forms EIA-1605 and EIA-1605EZ.

Figure 13. Methane Projects Reported, by Size of Methane Emission Reduction, Data Year 1997



Source: Energy Information Administration, Forms EIA-1605 and EIA-1605EZ.

than sending it to landfills, achieving 145,000 metric tons of methane emission reductions. Finally, UNICOM reported gas recovery activities at 13 landfills that reduced methane emissions by 104,000 metric tons. Excluding those three very large projects, the average methane reduction equaled 4,190 metric tons or 88,000 metric tons carbon dioxide equivalent (Figure 13).

Reducing emissions from waste treatment and disposal sites was by far the most frequently reported method for lowering methane emissions. The number of such projects reported grew by 22 percent from the previous reporting year and nearly tripled from 27 in the first (1994) reporting year to 79 in 1997. The principal reported method for reducing methane emissions from waste management and disposal is the capture of methane generated during the anaerobic decomposition of wastes in a landfill. The methane may be flared, used as a boiler fuel, or used to generate electricity, thus offsetting other, perhaps more carbon-intensive fuels. Other methods of lowering emissions from waste treatment and disposal include reducing the volume of waste reaching landfills through combustion or recycling, and capturing methane generated during anaerobic decomposition of organic material in wastewater. In addition to those projects that lowered emissions from waste treatment and disposal, 5 projects reduced fugitive methane emissions from coal mining, and 13 projects reduced methane emissions from leakage in the oil and gas system.

Reducing Methane Emissions from Waste Treatment and Disposal

The 79 reported waste treatment and disposal projects accounted for 637,000 metric tons of methane emission reductions in 1997, about 68 percent of all the methane reductions reported (Tables 8 and 9). Two-thirds of the reductions from waste treatment and disposal projects were reported as indirect (i.e., occurring at facilities not owned by the reporter). Seventy-four of the 79 projects reduced methane emissions from landfills, including 6 that lowered emissions through diversion of wastes that would have emitted methane during decomposition and 68 that captured methane from landfill gas generated at the waste disposal site (see box on page 33).

Despite the growth in the number of waste treatment and disposal projects, reported reductions appear to have declined (Table 9). The apparent decline does not represent an actual diminution in reduction activities. The decline is associated with a refinement of the emissions estimation methods for one large project. For previous data years, IWSA reported the annual reduction benefits associated with a stream of waste diversion activities going back to 1987, because emission reductions from such activities continue for many years. Together, the stream of waste diversion activities resulted in estimated emission reductions of 750,000 metric tons of methane annually. For 1997, IWSA chose to report only the reductions associated with the current year's waste diversion activities. Thus, the apparent decline in methane emission reductions reported by IWSA is the result of the exclusion of the effects from activities carried out in previous years. In both cases the

Table 8. Total Reported Methane Emission Reductions, Data Years 1994-1997
(Metric Tons)

Reporting Form	1994	1995	1996	1997
EIA-1605				
Direct Reductions	25,079	8,450	409,182	378,500
Indirect Reductions	102,642	1,077,289	1,157,068	477,055
EIA-1605EZ	24,523	50,555	53,739	79,365
Total	**152,244**	**1,136,294**	**1,619,989**	**934,920**

Source: Energy Information Administration, Forms EIA-1605 and EIA-1605EZ.

Table 9. Reported Methane Emission Reductions for Waste Treatment and Disposal Projects, Data Years 1994-1997
(Metric Tons)

Reporting Form	1994	1995	1996	1997
EIA-1605				
Direct Reductions	*	619	128,451	135,640
Indirect Reductions	99,433	1,061,709	1,142,896	422,773
EIA-1605EZ	24,388	50,325	53,007	78,625
Total	**123,821**	**1,112,653**	**1,324,354**	**637,038**

*Less than 0.5 metric ton.
Source: Energy Information Administration, Forms EIA-1605 and EIA-1605EZ.

Landfill Gas Recovery Reduces Greenhouse Gas Emissions

Between 1990 and 1997, the volume of methane in landfill gas captured in the United States doubled, from 1.2 million metric tons to 2.4 million metric tons. In 1990, about 0.9 million metric tons of methane were captured and used as an energy resource. The remainder was collected and flared. In 1997, 1.7 million metric tons were captured for energy and 0.7 million metric tons were flared. In 1997 an estimated 150 landfills were converting methane from landfill gas into usable energy, compared with just over 100 in 1990. This trend is expected to continue in response to EPA regulations. The New Source Performance Standards and Emission Guidelines require the collection and combustion of gas from all landfills with more than 2.5 million metric tons of waste in place and annual emissions of non-methane volatile organic compounds exceeding 50 metric tons.

Landfill gas-to-energy project reporting to the Voluntary Reporting Program has grown with national recovery trends. The 1997 reporting cycle included 68 separate projects that captured landfill gas from 80 different landfills. Eleven of the projects flared the recovered gas. Fifty-seven used the recovered gas as an energy resource, including 44 that burned the gas to generate electricity and 13 that injected the gas into pipelines for delivery to industrial boilers or the gas transmission system. Reported landfill gas-to-electricity projects lowered methane emissions by more than 320,000 metric tons. Reported landfill gas-to-pipeline projects reduced methane emissions by more than 110,000 metric tons. Altogether, reported reductions from landfill gas capture equaled 465,000 metric tons of methane. With 150 landfills known to have landfill gas-to-energy projects in place and 57 reporting to this program, more than one-third are represented in the data totals; however, only about one-quarter of the emissions savings from landfill gas-to-energy operations are reported, suggesting that some very large landfill gas-to-energy projects have not been reported.

Flaring methane after capture can also have significant emissions benefits. During combustion methane is converted to carbon dioxide. Methane has 21 times the warming impact of carbon dioxide per ton emitted. Thus, flaring methane and converting it to carbon dioxide can reduce its warming effect substantially. Reported reductions in this category for 1997 were just over 30,000 metric tons of methane, or one-twentieth of the estimated national total.

data reported were accurate, but the reductions reported reflect the estimation method chosen.

Recovery of Landfill Gas

As waste decomposes in a landfill it produces a biogas that is approximately 50 percent carbon dioxide and 50 percent methane. Because of the presence of methane, landfill gas has a heat content of about 500 British thermal units (Btu) per cubic foot, or about half that of commercially marketed natural gas. Thus, landfill gas is a potentially valuable source of energy. Because of its relatively low Btu content and the presence of several impurities, the typical method for using landfill gas has been to burn it for electricity generation rather than upgrading it for sale to a pipeline. The electricity generated is then sold to the grid. The process lowers methane emissions and reduces consumption of other fuels for electricity generation. When the electricity generated displaces oil- or coal-fired generation, carbon dioxide emissions are reduced.

In the first years of the Voluntary Reporting Program, landfill gas recovery projects were reported by electric utilities that purchased electricity generated at landfills. As landfill gas developers (those generating and selling electricity to the utilities) learned more about the Voluntary Reporting Program, however, they began to participate in larger numbers. In addition to emission reductions associated with energy sales, many reported reductions associated with the capture and flaring of gas without collateral energy sales. Naturally, the program participation of both electric utilities and landfill gas developers raises concerns about the potential for double counting. Where double reporting does occur, double counting is avoided because utilities report reductions as indirect unless they have an ownership stake in the landfill or its gas resource, while landfill gas developers report reductions as direct. Further, an analysis of the data has shown only three instances in which methane reductions at the same landfill were reported as direct and indirect reductions (Table 10). More recently, as electricity generated from landfill gas has grown less competitive with other fuel sources, there has been an increase in projects that pipe landfill gas directly to industrial boilers for use as a medium-Btu fuel.

Waste Diversion

When waste is diverted from a landfill through recycling, source reduction, or waste combustion, methane emissions that would have resulted when the waste decomposed at a landfill are avoided. Fourteen such projects that reported methane emission reductions were submitted to the Voluntary Reporting Program for 1997, including eight that were reported as recycling projects (see box in Chapter 3, page 25) rather than methane reduction projects. Together, those eight projects reduced methane emissions by a total of 2,300 metric tons. The six other waste diversion projects reported showed more substantial reductions. The Minnesota Resource Recovery Association (MRRA) reported four projects, including an MSW combustion project that reduced methane emissions by 20,190 metric tons. United Power Association reported a project to burn refuse-derived fuel, and IWSA reported reductions associated with the combustion of waste at facilities owned by its members across the United States. Because the IWSA project covered 65 waste-to-energy facilities, it reported a very large reduction of nearly 145,000 metric tons of methane in 1997.

Reducing Methane Emissions from Wastewater Treatment Plants

When wastewater is treated under anaerobic conditions, the decomposition of its organic portion yields methane. Like methane generated from waste at landfills, the methane generated from wastewater treatment may be captured and either flared or used as an energy resource. Because captured methane has value as an energy resource, operators may use an anaerobic digester to treat the wastewater and maximize methane generation. Five projects to capture methane generated from wastewater treatment were reported for 1997. The Platte River Power Authority and its four owner cities produce energy from methane collected at the City of Loveland wastewater treatment facility, reducing methane emissions by nearly 72 metric tons in 1997. Platte River also reported a second project that flared gas collected from the Longmont wastewater treatment plant. The gas was not used as a fuel because of its high sulfide content; however, the flaring lowered methane emissions by 226 metric tons. The City of Fairfield, Debourgh Manufacturing, and General Public Utilities also reported wastewater management projects.

Table 10. Landfills with Multiple Entities Reporting Reductions

Landfill Reported	First Reporter	Second Reporter
Martone Sanitary Landfill.	Zahren Alternative Power	New England Power
Hamm's Landfill	Zahren Alternative Power	General Public Utilities
Mallard Ridge	Wisconsin Electric	Wisconsin Power and Light

Source: Energy Information Administration, Forms EIA-1605 and EIA-1605EZ.

Reducing Emissions from Energy Production and Consumption

Reducing Emissions from Coal Mines

As coal is formed from organic material by natural chemical and physical processes, methane is also produced. The methane is stored in the pores (open spaces) of the coal itself and in cracks and fractures in the coalbed. As coal is mined, the pressure surrounding the stored methane decreases, allowing much of it to be released into the operating coal mine. Because methane in concentrations of 5 to 15 percent is explosive, mine operators use large fans to provide a steady airflow across the mine face and ventilate the mine shaft. Because the methane is valuable as an energy resource, mine operators may also employ degasification wells to capture methane and either inject it into gas pipelines or use it to generate electricity.

When a mine is closed it may continue to have significant although slowly declining emissions over many years. Northwest Fuel Development reported methane emission reductions of 236 metric tons in 1997 from a project to use methane recovered from abandoned coal mines to generate electricity. As the purchaser of electricity from the project, Pacificorp also reported associated indirect reductions.

The largest methane reduction project was reported by MCNIC Oil and Gas. MCNIC owns the gas rights for several very gassy mines operated by CONSOL in Buchanan County, Virginia. Total methane recovery from the mines equaled more than 228,000 metric tons in 1997, representing 93 percent of all reported methane reductions from energy production and consumption (Table 11). During previous reporting cycles, CONSOL has reported entity-wide reductions of methane emissions. In 1996, CONSOL reported direct reductions of 626,000 metric tons. Thus, the MCNIC project represents more than a third of all reductions achieved at CONSOL coal mines.

Reducing Emissions from Natural Gas Production, Transmission, and Distribution

Methane is the principal constituent of natural gas (about 95 percent of the mixture). Natural gas is released at several stages of gas production, from the transmission and distribution system through leakage, during normal maintenance, and, rarely, as a result of accidents. Thus, methane emissions can be reduced by replacing leaky system components, improving operations and maintenance, and limiting routine venting procedures. Thirteen such projects were reported for 1997, with an average reduction of 1,047 metric tons of methane per project. The largest projects were reported by three entities. NIPSCO industries lowered emissions by 2,600 metric tons; Western Resources reported two projects, one with reductions in excess of 6,000 metric tons; and Public Service Company of New Mexico reported a project that decreased emissions by 2,900 metric tons.

Reducing Emissions from Agriculture

Only three projects reported reductions in methane emissions from agricultural activities. In two cases, methane was recovered from the decomposition of animal waste in an anaerobic digester and used to generate electricity. As the purchaser of the electricity, General Public Utilities reported the projects. Methane was captured from dairy cow waste in the first project and from swine waste in the second project, with combined methane emission reductions of 1.4 metric tons in 1997. The third project was a study on reducing emissions from rice cultivation, financed by Houston Lighting and Power Company.

Federal Programs To Reduce Methane Emissions

The U.S. Government sponsors several voluntary programs targeted specifically toward lowering methane emissions. The programs, initiated under the Climate

Table 11. Reported Methane Emission Reductions from Energy Production and Consumption, Data Years 1994-1997
(Metric Tons)

Reporting Form	1994	1995	1996	1997
EIA-1605				
Direct Reductions	19,687	7,174	279,770	242,044
Indirect Reductions	0	3,543	4,039	3,653
EIA-1605EZ	135	230	732	741
Total	**19,822**	**10,947**	**284,541**	**246,438**

Source: Energy Information Administration, Forms EIA-1605 and EIA-1605EZ.

Change Action Plan in October 1993, are largely administered by EPA's Office of Air and Radiation. The most prominent are the Landfill Methane Outreach Program (LMOP), which works to promote the use of landfill gas to generate electricity or as a medium-Btu boiler fuel;[38] the Coalbed Methane Outreach Program (CMOP), which encourages the recovery and use of methane that otherwise would be emitted during mining operations;[39] and Natural Gas STAR, a program to promote cost-effective technologies and practices for emissions control in the natural gas industry.[40] Of the 100 projects to reduce methane emissions reported to the Voluntary Reporting Program for 1997, 30 were associated with the LMOP program, 2 with the CMOP program, and 6 with the Natural Gas STAR program.

The EPA and U.S. Department of Agriculture (USDA) jointly administer the AgSTAR program,[41] which aims to reduce methane emissions from animal waste. The USDA also sponsors the Ruminant Livestock Methane Program,[42] which seeks to lower emissions from enteric fermentation in domesticated livestock through improved feed and animal management. No projects associated with AgStar or the Ruminant program were reported.

There are also a number of regulatory and tax subsidy programs that are not specifically targeted at emission reductions but tend to have the ancillary consequence of lowering methane emissions. The New Source Performance Standards and Emissions Guidelines administered by the EPA require all landfills with more than 2.5 million metric tons of waste in place and annual emissions of nonmethane volatile organic compounds exceeding 50 metric tons to collect and burn their landfill gas either through flaring or as an energy resource. In addition to the estimated 600 landfills that currently flare gas, this regulation could affect as many as 500 additional landfills.

The Section 29 tax credit for alternative fuels has also affected methane emissions, prompting a large expansion in the use of both coalbed methane and landfill methane as a fuel source. The tax credit expired for coalbed methane on January 1, 1993, and for landfill methane in 1998. Legislative discussions currently underway could establish an alternative tax credit for landfill gas-to-energy projects.

[38] More information on this program can be found at http://yosemite.epa.gov/methane/home.nsf/pages/lmop.
[39] More information on this program can be found at http://yosemite.epa.gov/methane/home.nsf/pages/cmop.
[40] More information on this program can be found at http://www.epa.gov/gastar.
[41] More information on this program can be found at http://yosemite.epa.gov/methane/home.nsf/pages/agstar.
[42] More information on this program can be found at http://www.epa.gov/rlep/.